MODIS SEMI-ANNUAL REPORT: JUL/01/99 - DEC/31/99

Radiative Transfer Based Synergistic MODIS/MISR Algorithm for the Estimation of Global LAI & FPAR

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Summary of the algorithm. The objective of the contract is to develop a radiative transfer based synergistic algorithm for estimation of global leaf area index (LAI) and fraction of photosynthetically active radiation absorbed by vegetation (FPAR). The algorithm consists of a main procedure that exploits the spectral information content of MODIS measurements and the angular information content of MISR measurements to derive accurate estimation of LAI and FPAR. Should this main algorithm fail, a backup algorithm is triggered to estimate LAI and FPAR using vegetation indices. Both algorithms are capable of executing in MODIS-only or MISR-only mode, should cloud contamination, data frequency and spatial or temporal resolution requirements hinder a joint MODIS/MISR mode of operation. The MODIS-only mode of the algorithm requires a land cover classification that is compatible with the radiative transfer model used in the derivation. Such a classification based on vegetation structure was proposed and it is expected to be derived from the MODIS Land Cover Product. Therefore, our algorithm has interfaces with the MODIS/MISR surface reflectance product and the MODIS Land Cover Product. Validation of the LAI/FPAR product is an important part of algorithm development. Multiple validation techniques will be used to develop uncertainty information on Terra LAI/FPAR products. Successful validation will be accomplished if timely and accurate product uncertainty information becomes routinely available to the product users within two years after Terra's launch.

Summary of work performed during the second half of 1999 (January through June)

- Participation in the KonVEX field campaign. Data needed for validation of the LAI/FPAR product were collected, archived and analyzed.
- Validation of the LAI/FPAR algorithm with KonVEX data was carried out.
- Validation of the LAI/FPAR algorithm with data collected by German scientists at two sites representative of equatorial rain forest in Africa and coniferous forest in Europe was carried out. A paper describing validation results was submitted for publication in IEEE TGARS.
- Preparation has been made for SAFARI 2000 filed campaign.
- Estimation of expected quality of LAI/FPAR product with SeaWiFS data has been performed.
- QA process for simulated data has been taken during the Y-day test, MOSS-2 test, J-day tests and MOSS-3 test.
- Results from prototyping of the LAI/FPAR algorithm were presented at the Canada Center of Remote Sensing. A strategy to compare Canadian and MODIS LAI products was developed.
- Three lead talks were given at the second international workshop on Multianglar Measurement and Models in Ispra, Italy, Sep. 13-19, 1999.
- Invited talk on Vegetation Biophysical Products from TERRA at EOS-IWG in Vail, Colorado, in July 1999.
- Plenary talk on Remote Sensing of Vegetation Leaf Area at the Internation Union of Forestry Meetings (IUFRO 99) in Umeaa, Sweden, in August 1999.
- Invited talk on Comparison of ADEOS-2 POLDER and Terra MISR Global Products of LAI and fAPAR and their Validation at EOS Terra Core Sites and VALLERI Sites at the ADEOS-2 PI meetings in Kyoto, Japan, in December 1999.
- Six papers describing our MODIS scientific activities have been submitted for publication.

KonVEX Field Campaign

We (Yuhong Tian and Yujie Wang) participated in the KONZA field campaign during July 11-17, 1999, in collaboration with Dr. David Meyer, Jeff Morisette and Lou Steyaert. LAI and FPAR data were collected with LAI 2000 and Accupar instruments. The canopy reflectance data were collected with CropScan spectrometer. These data are currently under analysis. The preliminary results are reported below.

Canopy reflectance may be insensitive to a wide range of LAI values. In this case, the canopy reflectance is said to belong in the saturation domain. Therefore, the reliability of LAI values retrieved under condition of saturation is very low. The algorithm can recognize this situation and report its occurrence by assigning a special value to the QA parameter. Figure 5 demonstrates NDVI-LAI relationships derived directly from measurements and from canopy reflectance data using LAI/FPAR algorithm. The measured canopy reflectances with NDVI greater than 0.8 are insensitive to LAI values from the interval $2.5 \leq LAI \leq 7$. They belong to the saturation domain. The LAI/FPAR algorithm also attributed these reflectances to the saturation domain, i.e. QA parameter values provide correct information about quality of the LAI/FAPR product. Figure 6 shows the distribution of LAI values derived from field measurements and evaluated with the MODIS LAI/FPAR algorithm. The algorithm provides correct LAI values for canopy reflectance data being outside the saturation domain. It should be noted that the use of multi-angle information may result in decreased LAI values retrieved under a condition of saturation. The retrieval uncertainty is consequently reduced (Figure 7).

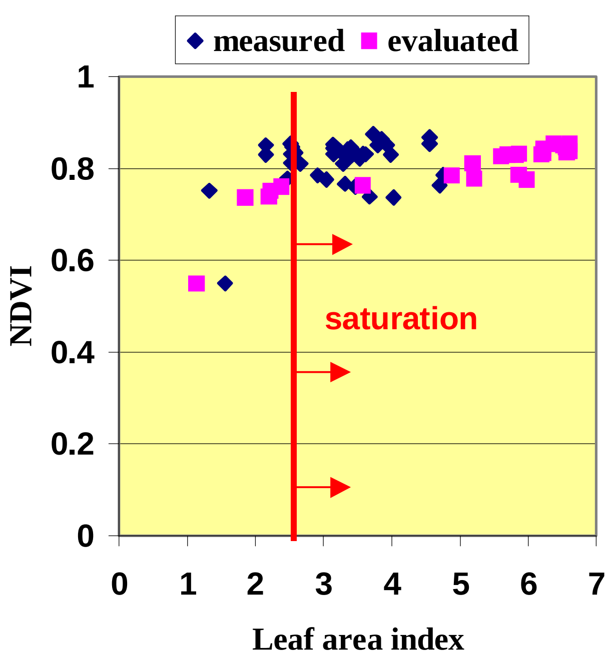

Figure 5. NDVI-LAI relationships derived directly from measurements and evaluated with the MODIS LAI/FPAR algorithm.

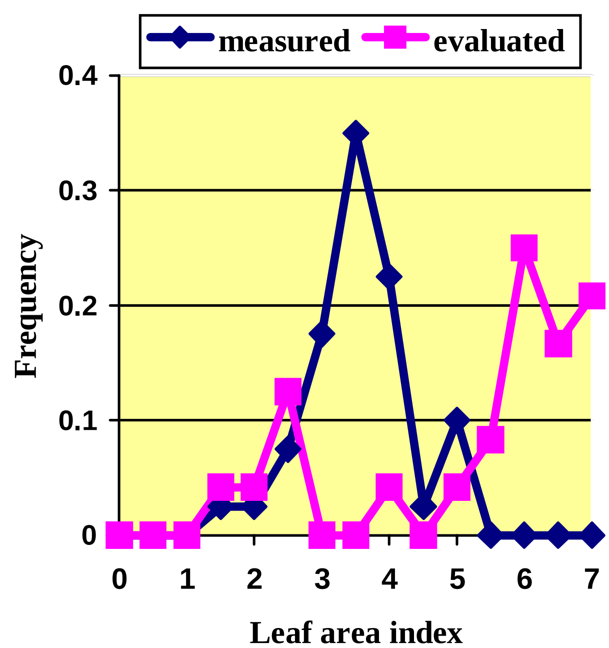

Figure 6. Distribution of LAI values derived from measurements and with the MODIS LAI/FPAR algorithm.

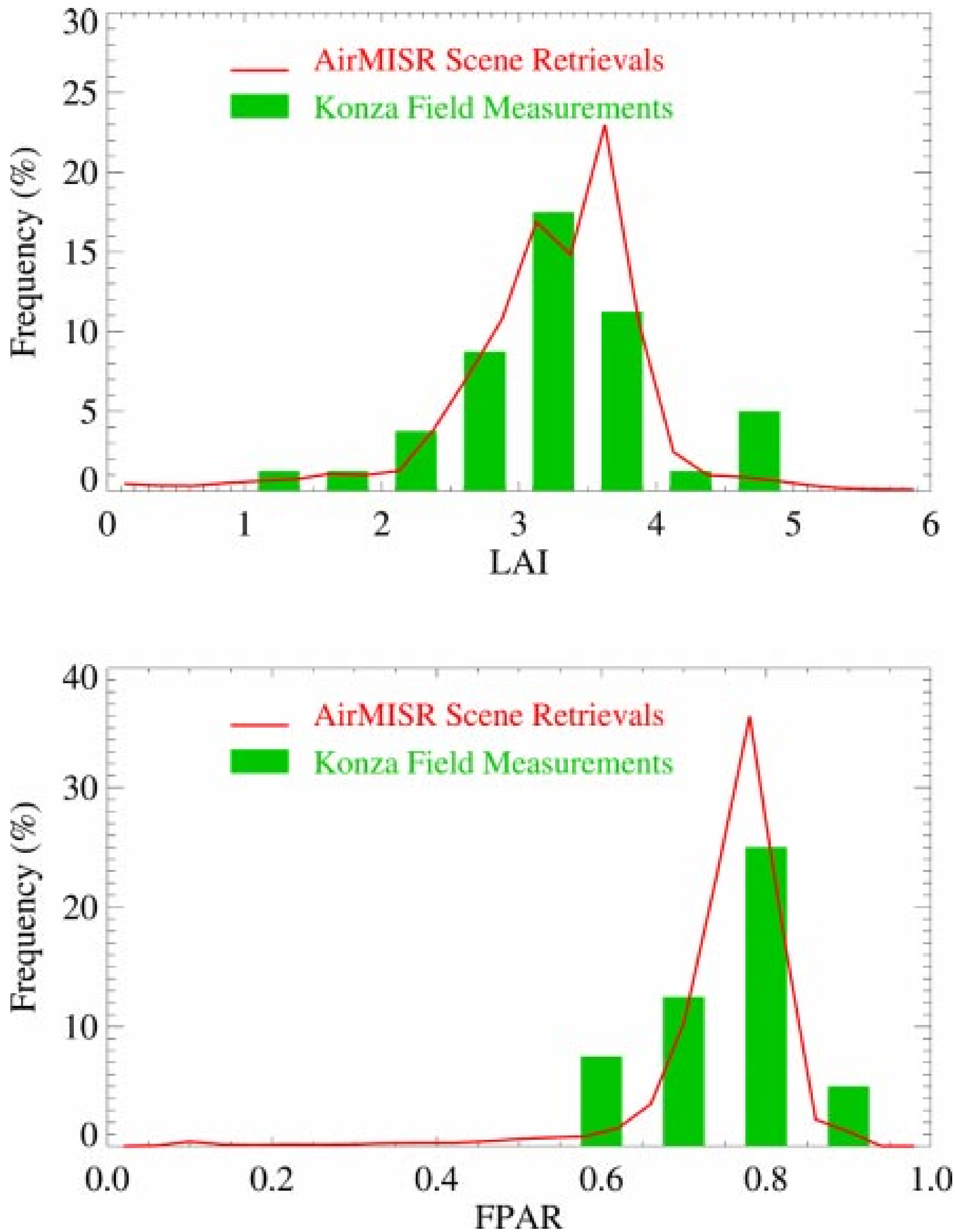

Figure 7. Distribution of LAI and FPAR values derived with the MISR version of the LAI/FPAR algorithm from AirMISR data acquired over Konza site.

Expected Quality of LAI/FPAR Products

Three variables are used to describe the quality of LAI/FPAR retrievals. They are the retrieval index, dispersion and the saturation rate. A better result should have high retrieval index, low dispersion and low saturation rate. We used SeaWiFS data at 443, 555, 670 and 865nm to estimate expected quality of MODIS LAI/FAPR product.

Figure 1 and 2 show uncertainties (dispersion) in LAI/FPAR retrievals and the retrieval index as a function of uncertainties in surface reflectance data. The pink, blue and red colored curves (Figure1) and bars (Figure 2) were derived without accounting for the dependence of e_{λ} on the spectral band λ, i.e., $e_{red}=e_{NIR}=e_{green}=e_{blue}$. Incorporation of the band specific uncertainties in the retrieval technique results in an increased value of the retrieval index. Band specific uncertainties reported by E. Vermote [*http://modarch.gsfc.nasa.gov/MODIS/RESULTS/DATAPROD/ MOD_09_accuracy.html*] were used to produce global SeaWiWS LAI/FPAR product. The SeaWiFS LAI/FPAR maps in 1998 are shown in Figure 3 and Figure 4.

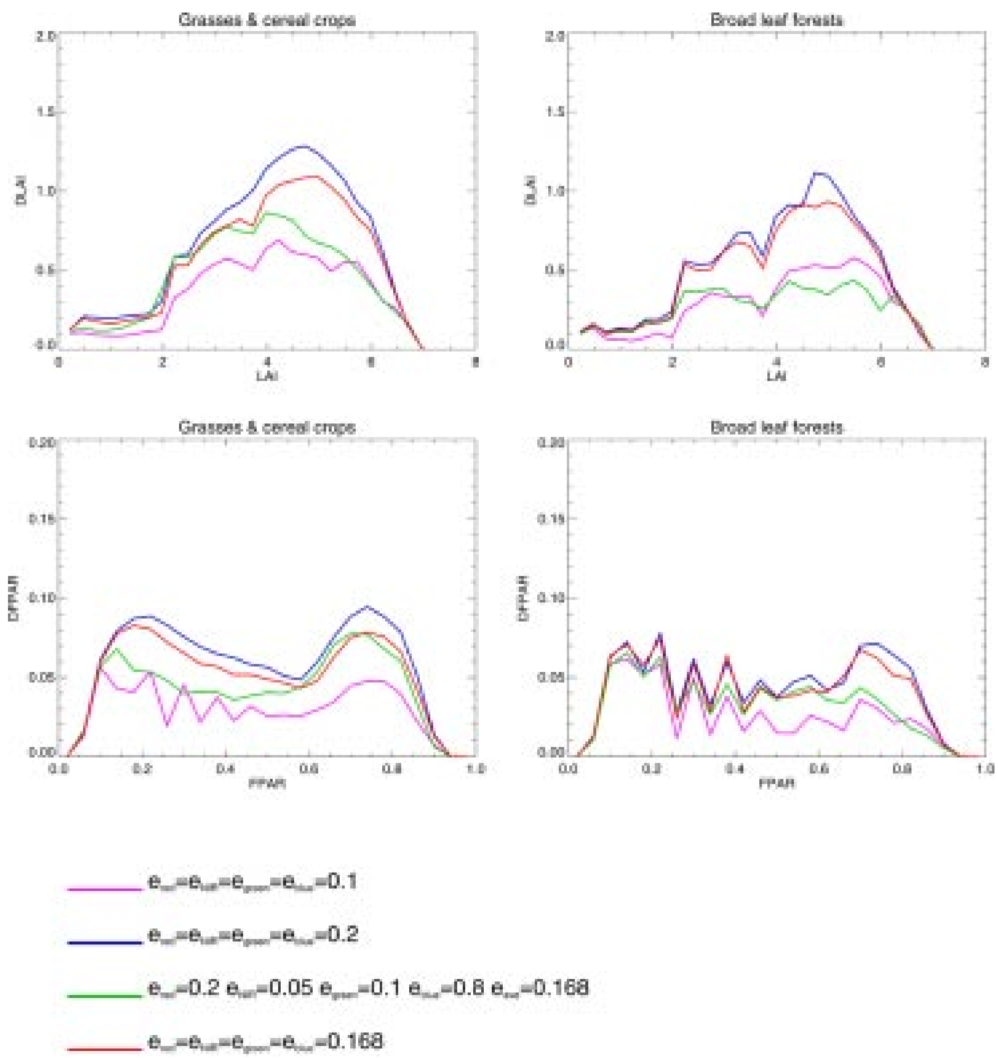

Figure 1. Uncertainties (dispersion) in LAI and FPAR retrievals as a function of uncertainties in surface reflectance data. Uncertainty $\sigma(\lambda)$ in surface reflectance r_{λ} at the wavelength λ is defined as $\sigma(\lambda)=e_{\lambda}r_{\lambda}$ (λ=red, NIR, blue and green spectral bands). We term e_{λ} a band specific uncertainty.

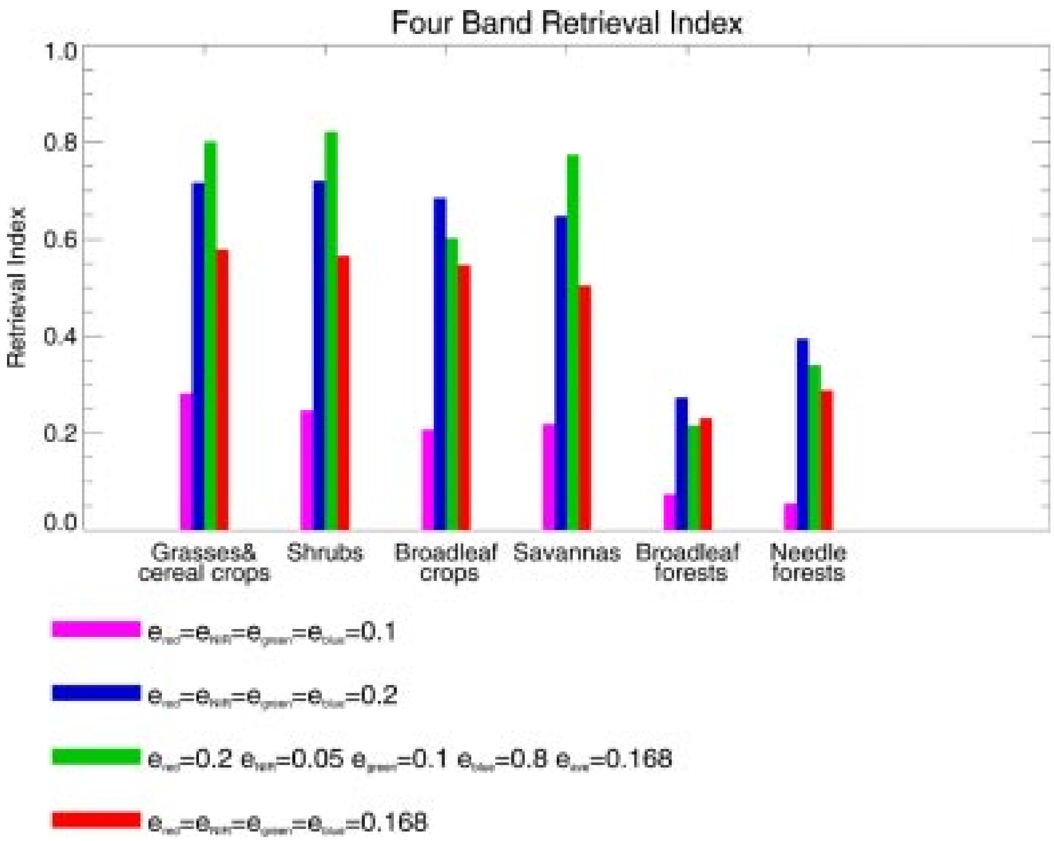

Figure 2. The retrieval index as a function of uncertainties in surface reflectance data. The meaning of e_λ is the same as in Figure 1.

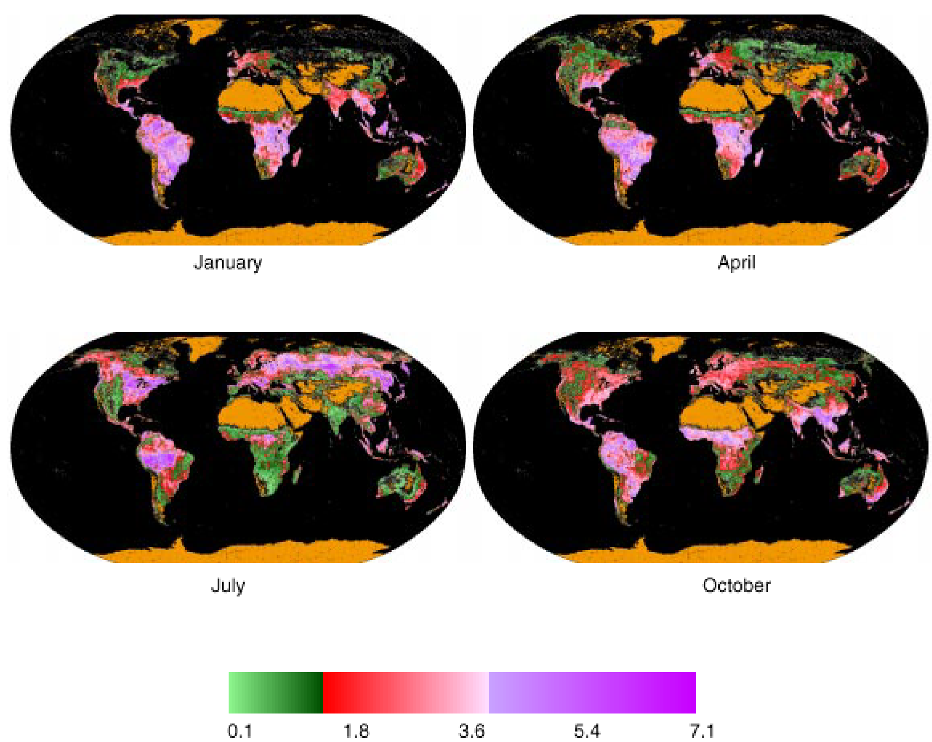

Figure 3. The SeaWiFS LAI map in 1998.

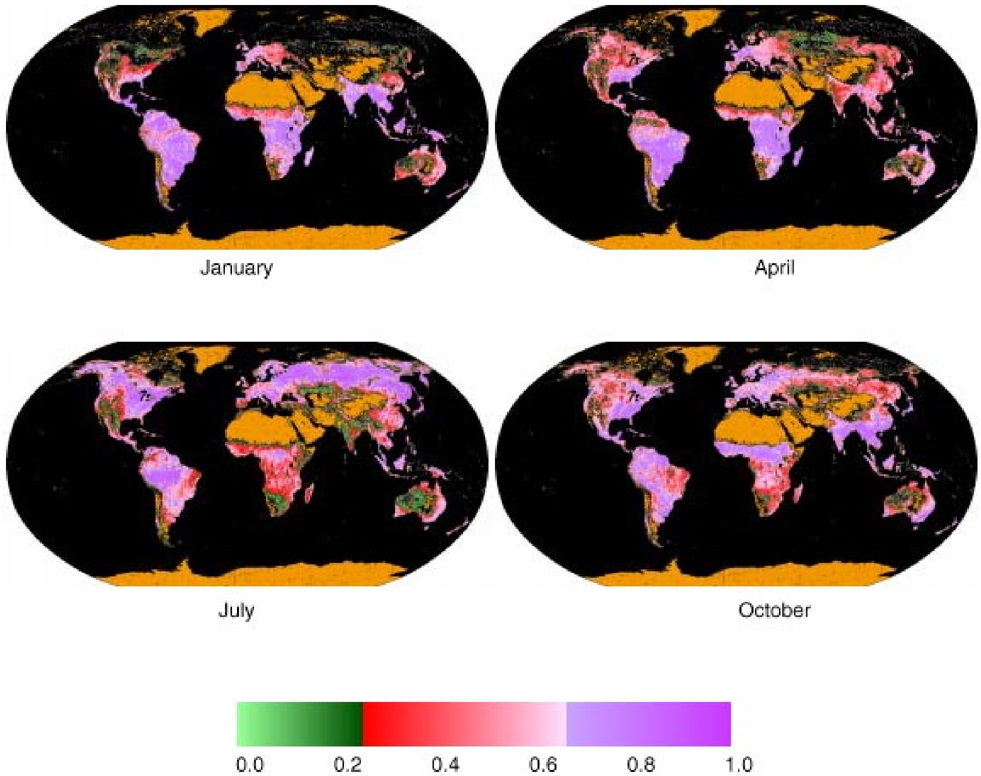

Figure 3. The SeaWiFS FPAR map in 1998.

LAI/FPAR Algorithm Research Group QA Activities and MODLAND QA Tests Participation

The Quality Assurance (QA) is an important part of MODIS products. Quality control procedures of EOS products and the archival of quality control data within the product metadata are important aspects of EOS and EOSDIS. The objective of products' QA is to satisfy user expectations. Poor quality data products will be identified and flagged before their release to the public. This requires the operational flagging of products to be processed at both automated and manual levels in order to identify the quality of products which obviously and significantly do not conform to their expected accuracy.

The QA operational goal is to process about 5~10% of the land tiles (about 15 to 30 tiles in total 289 land tiles global) when data are received from MODIS instrument and PGEs are running. Problems in product code may still exist and operational experiences are necessary to smooth future work. A series of MODLAND QA tests conducted by MODAPS are designed for this goal. Our group actively participated in these tests, successfully tested the functions of data ordering systems and identified many problems in both PGE and the operational process. Below, there is a summary of those activities conducted by our group.

Name of Test	Test Focus	Time	Notes
N-day Test	PI Processing test	March 16 to April 12, 1999.	
Description: L4 LAI/FPAR Daily (PGE33) MOD15A1 products were made from Julian days 223-224, 1997.			
X-day Test	PI Processing test	May 20-June 11 1999.	Rerun of the N-day test
Description: Daily L3 MODLAND products (include L4 LAI/FPAR Daily) were made from simulated MODIS L1B, Geolocation and Cloud Mask products for 1997 Julian days 223-225.			
MOSS-2 Test	Official end-to-end test	July 27-28, 1999.	Entire ground system test
Y-day Test	PI Processing test	July 29-Dec. 15, 1999.	
Three cycles of L3 8-day products (days 53-56, days 49-56 and days 57-64, 1999). The available products interest are: L4 LAI/FPAR Daily (PGE33) MOD15A1 L3 LAI/FPAR 8-Day (PGE34) MOD15A2 L3 Aggregation Daily (PGE22) MODAGAGG			
MOSS-3 Test	Official end-to-end test	Oct. 18-22, 1999	Entire ground system test
Description: EDG data ordering system was successfully tested.			
J-day Test	The joint MODAPS and DAACs test	Nov.22-Dec. 23, 1999.	
Description: Similar activities to Y-day test for LAI/FPAR products (MOD15A1, MOD15A2)			

1. Data metadata query from LDOPE QA database. Available data can be queried from the LDOPE QA database according to the product name, acquisition date, processing date, tile granule ID and tile QA quality values, etc. Often, the most recently produced tiles with 50% or more in QA percentage in good quality are selected. If the number is too large, golden tiles are selected for analysis only. Corresponding MOD15A1, MOD15A2 and upstream product MODAGAGG are selected together to put an order. This helps to identify problems when output results are not good.

2. Data ordering from MEBDOS. This process involves the activities of "Query and Search" data from the LDOPE QA database mentioned above and then ordering them from MEBDOS. The easiest way is to use granule IDs.

In MOSS3 test, for example, 16 MODAGAGG and MOD15A1 files were produced in day 229 (Oct. 20) of total 1.4GB on Oct.21 and were downloaded on Oct.22. The time slip between the order placed to acknowledge email received is about 19 hours. The data download speed is fast, approximately 300Kbytes/s. Further QA of the data has been processed.

A small discrepancy in that of LDOPE QA database's function was reported to David Roy. The function, "save core metadata", present some old data information that did not belong with the matched Search results.

3. Data ordering from EDC via EDG. There are two ways used to order from EDG. Manually ordering data includes setting up personal profiles in the EDG database searching engine, selecting interested products and arranging searching, selecting datasets and granules from searching results, setting up ordering methods (ftp/tape) with a “shopping cart” and finally placing the order.

During the MOSS3 test, two orders are placed manually both for ftp pull and 8mm tape. The searching time ranges from 1 to 10 minutes and the lag of email response is 5 hours or less. The ftp speed was about 100Kbytes/s, an average, and the tapes have been received within one week.

There are some suggestions for the interface of EDG based on our experience:
(1) MODIS products use only descriptive names without ESDT names, making it difficult for user to identify them. For general users, it is also good to know the more often used ESDT names.
(2) Usually, the granule files of a search result are over a hundred and it is inconvenient for user to pick them up one by one. If criteria of granule location are added, the process will be much easier.
(3) When selecting order options, either ftp pull or tape should be selected in one search. After selection, it is better to replace the "Ready" to either ftp or tape to identify the option used.
These have been reported to EDG.

Subscribed ordering can dramatically speed up the ordering process for a series routinely required products. Subscription tests were done on Oct. 20, eight orders for subscription were received on Oct. 20 and 21 for both ftp pull and tape. A total of 2.1GB data have been downloaded from EDG and QA checking on the products was done.

EDG can also support ftp push, which will be especially useful in the future when continuous data are received. The anonymous ftp push service is now ready on our site and the subscription mechanism works for ordering data with ftp push.

There are some suggestions on subscriptions:
(1) Subscriptions should have more control criteria such as an assigned list of granule locations.
(2) ECS Notification email about ordering should contain more information about when and where the order is placed. Currently, it is hard to distinguish whether the order is placed manually or from a subscription. Therefore, the consistency is hard to check.

4 QA data checking for products. Some severe defects in the definition and regulation of QA data interpretation and propagation have been found and closely traced in MOD15 products. After communicating with University of Montana group and LDOPE, "MODLAND QA Bit Redefinition Recommendation" by D. Roy and R. Wolfe was proposed to solve the existing problems.
The recommended new definition of the MODLAND QA bits is:

00 - Pixel produced, probably clear, good quality, not necessary to examine more detailed QA bits.

01 - Pixel produced, probably clear, unquantifiable, or other than good quality, recommended examination of more detailed QA bits.

10 - Pixel produced, possibly cloudy.

11 - Pixel not produced.

The implementation of the new QA bit logic follows 2 rules:

Rule #1: Do not discard a pixel simply because it is apparently cloudy. Let the PGE run and produce the best assessment possible for the product under these conditions as if there was no cloud mask.

Rule #2: Set the QA bits to 10 where the input says it is cloudy.

These changes on the definition of QA will help the products to be more accepting of unexpected inputs in the early day of data processing.

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